The use of remote cameras at the nestboxes of arboreal mammals, Brush-tailed Phascogale *Phascogale tapoatafa* and Sugar Glider *Petaurus breviceps* in the Rushworth State Forest

Fauna Survey Group Contribution No. 26

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Abstract

The Fauna Survey Group of the Field Naturalists Club of Victoria has a program for monitoring nestboxes in the box-ironbark forests near Rushworth, Victoria. In addition to its normal monitoring program, in May 2012 five remote cameras were set up for 23 nights with a view to monitoring the Sugar Glider and Phascogale activity at selected sites. The cameras produced images of nestbox inhabitant activity, as well as that of some visitor animals. At face value the results of this simple survey provide support for previous research into the behaviour and activity of the target species around nesting sites. The images showed that both species are active only between dusk and dawn, they both have periods of inactivity and both use multiple nesting sites; however, there were also gaps in 'evidence', which demonstrate that some camera settings and site set-up processes need to be adjusted to increase the confidence in any findings. (*The Victorian Naturalist* 131 (1) 2014, 15-23).

Keywords

Introduction

Box-ironbark vegetation in Victoria once covered approximately 965 000 ha, but by 1993 had been reduced to around 275 000 ha (Environment Conservation Council 1997). This change has taken place largely due to a combination of agriculture, mining and forestry. In addition to the reduction of total tree cover, there has been a significant change in the forest structure. One change has been the reduction in hollow-bearing trees (Traill 1991), which provide habitat for a range of biota, including arboreal mammals.

Artificial nestboxes have proven to be successful in providing habitat for arboreal mammals and contribute to their management and conservation (Beyer and Goldingay 2006).

Ninety-two nestboxes were constructed and placed in the forests near Rushworth in 1992 by the Australian Trust for Conservation Volunteers (Soderquist *et al.* 1996). Since then the nestboxes have been monitored, maintained and supplemented by the Fauna Survey Group (FSG) of the Field Naturalists Club of Victoria (FNCV). There are now 145 nestboxes.

The nestbox-program takes the form of a physical count of nestbox inhabitants and the type of nest.

Sugar Glider *Petaurus breviceps* and Brush-tailed Phascogale *Phascogale tapoatafa* (hereafter Phascogale), are the main users of these boxes, but other species such as the Squirrel Glider *Petaurus norfolcensis*, Yellow-footed Antechinus *Antechinus flavipes*, Common Brushtail Possum *Trichosurus vulpecula* and Common Ringtail Possum *Pseudocheirus peregrinus* have been recorded also (Myers and Dashper 1999). In Victoria, the Squirrel Glider is considered to be endangered, while the Phascogale is considered vulnerable (DSE 2013).

Phascogales are small, carnivorous, arboreal marsupials occupying dry forests (Cuttle 1982). The species exhibits an annual post-mating male mortality (Cuttle 1982). With rare exceptions they are nocturnal (Scarff *et al.* 1998). Both sexes are solitary in nature (Soderquist and Ealey 1994). Sugar Gliders are also nocturnal and arboreal, but unlike phascogales, live in nesting communities (Smith 1973). They are omnivorous, feeding predominantly on plant exudates in autumn and winter and insects in spring and summer (Smith 1982).

A number of studies have examined the activity of these species around the nesting or roosting sites.

This study uses remote cameras to investigate their success in monitoring activity of Phascogales and Sugar Gliders.

The positioning of an external camera has its limitations, but could be expected to reveal or confirm behaviours such as the hours of occupation, the number of occupants and any predator activity. Any issues with the cameras, or their deployment, should also be revealed. How cameras might be used to further the knowledge of the nestbox inhabitants is also considered.

Methods

On the weekend of 12 and 13 May 2012, the FSG carried out its annual survey of the nestboxes. Each box was inspected and the species inhabiting them recorded. The inspectors were asked to identify those occupied boxes where adjacent trees would allow for remote camera monitoring. Five boxes were selected from these descriptions. At the time of inspection, two of these selected nestboxes contained multiple numbers of sugar gliders (cameras 4PB and 5PB) and three contained single phascogales (cameras 1PT, 2PT and 3PT). Four of the cameras were set up on the same day as the box inspection; one was installed on the day after.

Camera site selection was based on the best tree available. The cameras were fixed to the nearest convenient tree, adjacent to the nestbox and at approximately the same height. They were fixed by way of an External CCD Camera Housing Mounting Bracket, supplemented with a wooden frame and ant-cap for protection and support (Fig. 1). The entry hole was visible in all nestboxes except one (4PB).

The cameras were between 1.3 and 4.1 m from the nestbox. Camera 1PT was 2.3 m away, 2PT (2.8 m), 3PT (3.0 m), 4PB (1.3 m) and 5PB (4.1 m).

Four of the cameras were Ltl Acorn 6210 MC and the other a Faunatech Scoutguard DTC-530. The Ltl Acorn cameras (each having an 8 GB memory card), have the functionality to take still and video images at the one trigger event and were set for three still shots (stills) and a 60 second video. The Scoutguard (with a 2 GB card and the functionality to take either still or video shots) was set for a 60 second video. There was a three minute interval between trigger events. All cameras were set for 24 hour action and normal sensitivity. They were also set with the time stamp on, which meant that date and time were recorded on all images. Temperature was recorded on the Ltl Acorn stills.

Fig. 1. Camera set-up.

According to the product manuals, the trigger time for the Ltl Acorn cameras is 1.2 seconds with 1.0 second between shots (with the date stamp on) and the Scoutguard trigger time is 1.3 seconds. This meant that because the Ltl Acorn took three stills first, the video triggered after approximately 4.2 seconds.

All cameras were set to take the best quality images available. For the Ltl Acorn the stills were set for 12 megapixel shots and for 1440 x 1080 video, with the Scoutguard set for 640 x 480 video. All cameras had been operated in the field previously and had produced images.

All the cameras were passive infrared (PIR) cameras. These cameras trigger in response to changing temperature, generally associated with movement. The cameras take colour images during the day and black and white at night. All the images were analysed twice to identify their contents, with those containing a phascogale or sugar glider then being analysed in more detail.

The duration of the trigger event was calculated from the time an animal first appeared to the time it disappeared from view. The duration included the initial camera response time and the time between shots. An appearance of an animal after the first animal disappeared was not included in this assessment.

The nestboxes were checked when the camera was retrieved and only site 1PT was vacant.

Results

In total there were 278 trigger events producing a total of 1122 images including videos. There were 131 events showing animal images (animal triggers). This leaves 147 trigger events where the images did not show an animal. These have been recorded as non-animal triggers, although it is possible that they were triggered by an animal which was not recorded.

The species recorded were largely nestbox occupants. Other species recorded were Eastern Grey Kangaroo *Macropus giganteus* (4 trigger events), Laughing Kookaburra *Dacelo novaeguinea* (1), Flame Robin *Petroica phoeniecea* and a treecreeper in the same trigger event (1) and a sugar glider near a phascogale nestbox (1).

The still images on the Ltl Acorn ranged from 0.5 to 1.2 Mb in size and the videos from 43 to 52 Mb. The Scoutguard videos were approximately 70 Mb. The memory cards for 2PT and 4PB were full.

Three of the cameras produced images of animals, two at the Sugar Glider boxes and at one of the Phascogale boxes. The other two cameras produced no animal pictures. The results for each camera are summarised below (Table 1).

General observations were that most entry and departure was from the top of the box and animals had no difficulty grasping the 19 mm box lid and manoeuvring their way in and out of the entrance. As an example of speed of movement, one video replay shows that one Sugar Glider covered around 4 m in less than one second.

Camera 1PT produced one trigger event, which occurred as it was being taken down from the tree during collection. In an unrelated test, camera 1PT was shown not to trigger in the dark.

Camera 2PT (Fig. 2) shows four phascogale trigger events, on days three, seven and 12. The sequence was leaving the box, then entering, then leaving then entering. One event showed the phascogle bringing nesting material to the box. The first image always showed the animal out of the box, there being no image of the phascogale actually leaving the nestbox hole.

Table 1. A summary of the output from each camera, showing number of the day on which it was last triggered (maximum possible = 24), the total trigger events and the number of those showing animals (animal trigger events).

Camera number	Last working day	Total number of trigger events	Number of animal triggers events
1PT	23	1	0
2PT	12	108	5
3PT	11	5	0
4PB	19	141	104
5PB	23	29	22

The other animal trigger event was that of a Sugar Glider, on the tree, but not approaching the nest.

Camera 3PT produced 5 trigger events on day 1 at start up (1), day 2 (1) and day 11(3). There were no animal images.

Camera 4PB (Fig. 3) shows regular departure and entry activity on the 19 days of operation. As best as could be seen (this camera did not cover the nestbox hole), the animals entered the box around dawn and did not leave until early the following evening. There were more trigger events around the re-entry time than at the time the animals left the nestbox.

Every second or third night (days 2–3, 4–5, 6–7, 9–10, 12–13 and 16–17) there were no animal trigger events for around 20 hours (between around 0600 hours to 0200 hours the next day); however, there were non-animal trigger events (mostly single events) during this period and most took place around 1800 hours.

Camera 5PB (Fig. 4) shows Sugar Glider trigger events on most evenings, with three one-day gaps and one three-day gap. All these events were in the evening and only one showed a Sugar Glider entering the nestbox. In no cases did the first image of a trigger event show the Sugar Glider exiting the nestbox; it was always on the tree.

Total trigger events (n=278) occurred throughout the day, but animal triggers (n=131) occurred mainly between dawn and dusk. All

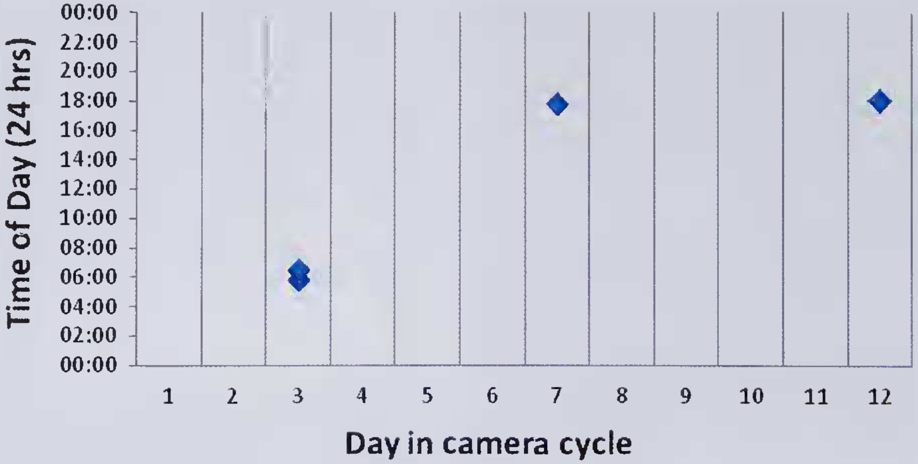

Fig. 2. The times of Phascogale trigger events from camera 2PT.

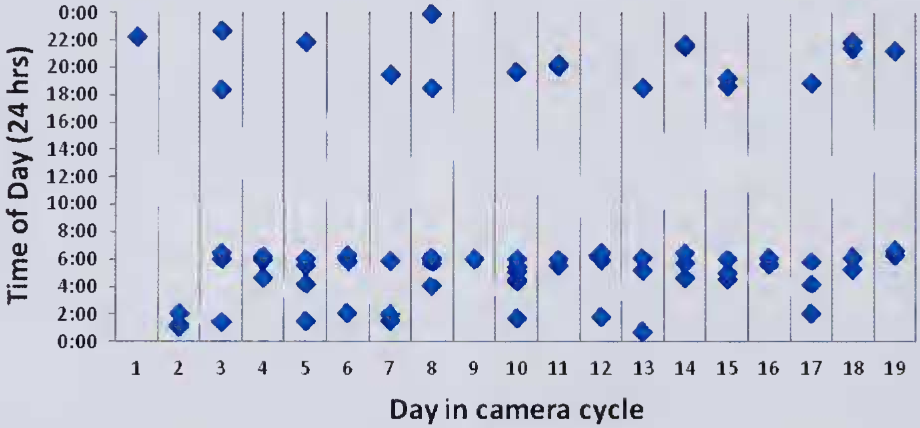

Fig. 3. The times of Sugar Glider trigger events from camera 4PB.

Sugar Glider and Phascogale triggers (*n*=125) occurred during this time. Non-animal triggers (*n*=147) occurred mainly in daylight hours. Many non-animal trigger events appeared to be caused by the movement of the tree on which the camera was attached. Fig. 5 contains a summary of the timing of events.

The maximum exposure time for any one event, given the three minute interval between shots, was around 63 seconds (three stills plus the 60-second video). There was no way of establishing the time an animal stayed around the nestbox if it was still there after the completion of the video. The three minute interval between triggers, combined with multiple animals in some nestboxes, made it impossible to be sure that consecutive trigger events showed the same animal. As seen in Fig. 6, below, the majority of trigger events (63%) were of less than 20 seconds' duration. Some 23% took less than 3 seconds.

Discussion

This project has given us the opportunity to review the use of the cameras, particularly in

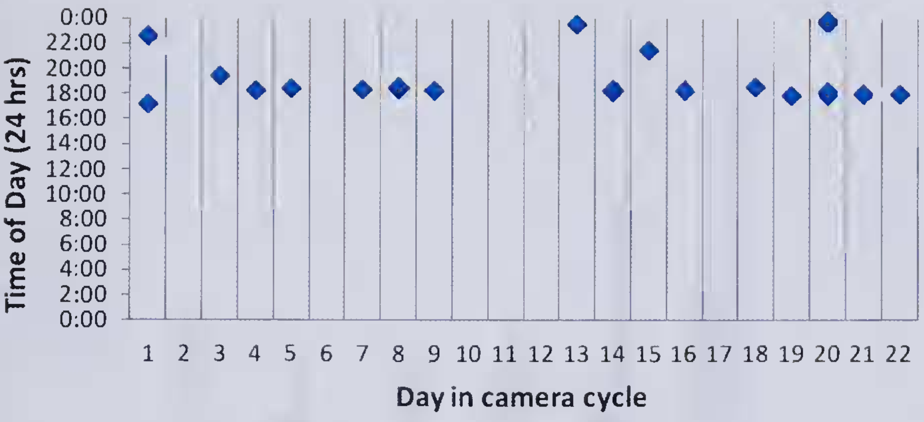

Fig. 4. The times of Sugar Glider trigger events from camera 5PB.

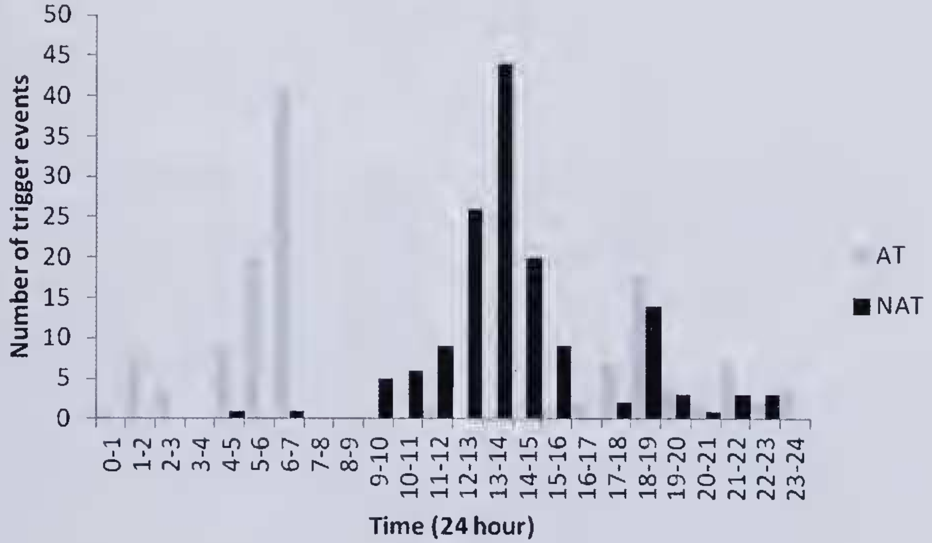

Fig. 5. A comparison of the time of day between animal (AT) and non-animal trigger events (NAT).

regards to monitoring nestboxes. The results showed that data about nestbox usage could be successfully obtained by using relatively inexpensive remote cameras. Passive infrared cameras have been shown to be effective in recording movement events (Dixon *et al.* 2009).

The findings cover issues of animal behaviour and camera performance, settings and siting.

Animal behaviour

Unfortunately, only one of the three cameras set to monitor Phascogale activity produced animal images. Even though there were only four phascogale events, the 12 days that the camera was in operation appeared to be characterised by extended stays in the box. According to the images, it was two days before the animal left

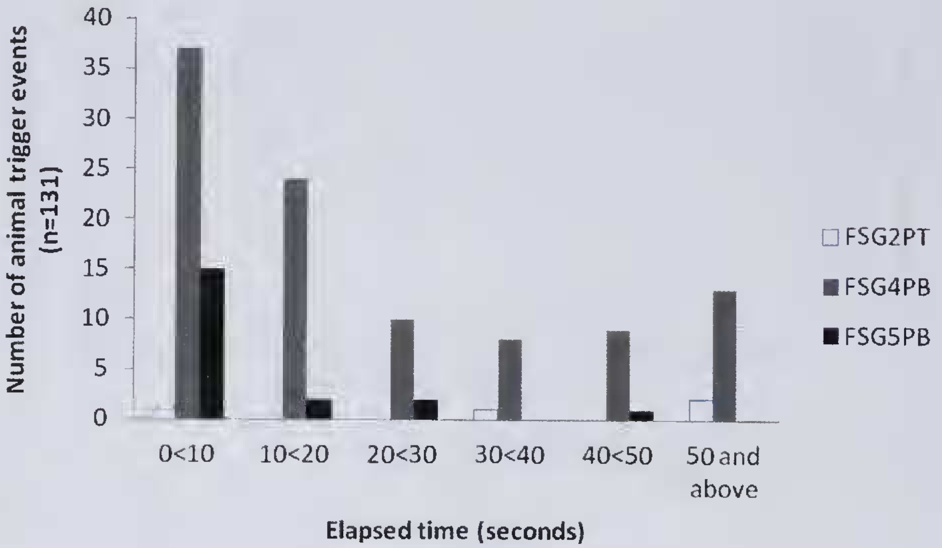

Fig. 6. Length of time of animal activity in trigger events containing Sugar Glider and Brush-tailed Phascogale nestbox occupants.

the box, and then only for around 40 minutes. This was followed by another four days in the box. (Periods of inactivity have been noted previously [Scarff *et al.* 1998], but for much shorter periods.) It was then another four days before the animal returned. The use of other roosting sites is not unusual and elsewhere Phascogales have been shown to use 19 nest trees (van der Ree *et al.* 2001) with their home range covering up to 150 ha (Soderquist 1995).

This nomadic lifestyle of the Phascogale makes it impossible to obtain any regular images from one camera. In addition to where an animal will be from one night to the next, it is very difficult to confirm the identity of the camera subject (Kays and Slauson 2008) without other techniques such as marking or radio tracking; however, during family rearing time, the female creates a nursery site which is occupied from when the lips of the young separate (about 48 days), until the family disperses (Soderquist 1993b). In a study of three Phascogale populations (Soderquist 1993a), births took place between mid-June and early August. Weaning takes place at about 100 days and the mothers leave the nest at around 140–150 days. Camera monitoring of nursery sites proves useful in studying the behaviour of the female and later the young. Some effort would be needed to identify such a site.

The cameras at the two Sugar Glider sites produced a more sustained sequence of images. Although these animals also change nest sites, their home range is much smaller (0.5 and 0.7 ha) than that of a Phascogale (Suckling 1984). Given that Körtner and Geiser (2000) found that movements tended to be infrequent, the species appears to be a better candidate for nest site monitoring by camera. Our results showed that both sites were in use for the extent of the camera operation.

The results at camera 4PB support previous findings of periods of inactivity (Körtner and Geiser 2000). Their study associated reduced foraging with cold or rainy nights. Bouts of torpor of between two and 23 hours were also associated with cold and rainy nights. The results from 4PB suggest that reduced activity occurred on six of the 19 nights. Some caution is necessary here. Although this camera showed most of the nestbox, it did not show the entrance hole or any of the tree from below. While the results on all cameras showed animals to approach the nest from above, it is possible that their activity would not be registered if the occupants of camera 4PB approached from below. It is also possible that the non-animal triggers occurring around 18:00 hours were caused by activity from this nest box, but no animal image registered.

None of the images of other species around the nestboxes revealed anything relevant to the occupants of the nestbox. Laughing Kookaburras have been known to prey on young Sugar Gliders (Suckling 1984). It could be argued that the time of 5 pm was relevant in that it is close to the time when Sugar Gliders leave the nestbox, but there was no behaviour to suggest that the nestbox was being used for anything other than a perch. The bird was not there after the 3-minute camera delay interval.

Sugar Gliders have been known to use nestboxes previously occupied by Phascogales (Myers 1997), but the single image in this study gave no clue to any change in tenancy. Other species detected were incidental to the nestbox occupants.

Camera issues

The 'experiment' revealed that a number of camera-related issues need to be addressed to improve the quality of outcomes in any further studies. It is possible that some of the results were compromised because of these issues. It is also possible that these cameras, at the less expensive end of the market, are not designed to cope with some of the demands of this project. The issues relate to the management of disk space, some of the camera settings and the setup processes.

Two of the cameras ceased to work because of a lack of available disk space. The chances of this happening can be reduced by increasing the size of the memory card as the cameras can take memory cards of up to 32GB. However, this could also mean an increase in unproductive analysis time, given the ratio of animal to non-animal triggers. The amount of disk space used can also be reduced by making a change to the camera settings, which are discussed below.

Trigger interval

The trigger interval was set for three minutes, largely to reduce the non-animal triggers caused by non-biotic temperature change and to conserve disk space. This proved ineffective and counterproductive, as two of the cameras reached their capacity anyway and there is a good chance that some activity was not captured as a result of the gap. Given that much of the activity around the box lasted less than 20 seconds, it is almost certain that animals leaving in the 3-minute gap following the first wave of departures were missed. It is therefore suggested that the cameras be set for the minimum interval available. This will eliminate, to the best of the camera's ability, any missed activity.

Image type and duration

Still images gave little indication of the animals' movement or behaviour and actually added three seconds to the start of the video which, with its extra shots per second, provided more useful data. As the majority of events were over in less than 20 seconds there is no need for a 60 second video. Overall, shorter videos with no stills would be more informative.

Timer

The cameras were set for 24-hour action. All the activity involving the nestbox occupants occurred between dusk and dawn. The timer setting on the cameras can be activated to monitor only this time period. This change eliminates the majority of the non-animal trigger events, reducing disk capacity issues.

Image quality

Another option to reduce the use of disk space is to select a lower video resolution setting (pixels per frame). Although this reduces the quality of the videos, it also reduces the amount of disk space required (Ltl Acorn undated). In this case, animal identification is not a key issue and therefore resolution may be sacrificed.

Sensitivity

The camera instructions suggest using low or normal sensitivity for external use, largely to reduce the effect of extraneous movement. A high setting is also recommended for high temperatures in order to distinguish a warm body from the ambient temperature. Given night-time use, where it would appear non-animal images are at their lowest, it might also be prudent to maximise the sensitivity setting to optimise the chances of recording an image.

Non-use of the time stamp

Both camera types have the facility to have the date and time-stamp on or off. The trigger speed can be increased by 0.5 seconds if this facility is not used (Ltl Acorn, undated). Although the reviewer of the images can be inconvenienced by not having this information on the image itself, it is still available on the memory of the camera disk. The extra speed appears valuable in these circumstances.

The results also showed that a number of the set-up techniques could be improved.

Siting

The speed at which the animals appeared to leave the box suggests that it is important to have the camera in a position where it has the earliest possible exposure to any movement. Detection would be enhanced if the camera was facing the nestbox hole because the animal is likely to trigger the camera as soon as it puts some part of its body in the camera's view.

Distance from camera to nestbox

Camera 4PB was sited 1.3 m from the nestbox and this produced two issues. Flaring (a bright patch that reduces picture quality) in images on this camera suggests a need to increase the distance to improve subject clarity. Flaring can also be reduced by placing packing tape over the camera flash (M Weston pers. comm.). The translucent nature of this tape still allows satisfactory pictures to be taken.

At 1.3 m not all the box was contained in the image. Increasing the distance would overcome this problem, as well as capturing more of the immediate area. This broader view is recommended to allow for the speed of movement of both species, but in particular the Sugar Glider.

Camera 5PB results show a pattern of gliders leaving the nestbox, but not returning. Even though the camera had only a side-on view of the nestbox there was no apparent issue with trigger events when the animals left the nestbox. Given this, and Sugar Gliders' propensity to enter and leave from the top, there is no reason to suspect that they could enter without being in view of the camera. There may be some reason that the Sugar Glider did not trigger the camera on the return journey. A combination of cold fur, small body and the 4.1 m camera distance (this set-up had the greatest distance between camera and nestbox), may mean there was insufficient temperature difference between the animal and the ambient temperature to register. A reduction in the camera to nestbox distance and the setting of the sensitivity to high (as mentioned above) may improve results.

The results suggest that a distance of 2–3 m would produce improved outcomes.

Time of set-up

In the case of camera 3PT (which had an excellent view of the nest box), the set-up was completed the day after the phascogale presence was recorded. The box was not re-checked on the day the camera was erected. Given the previous discussion on phascogale movement, it is essential that the box is checked at the time of camera installation, otherwise it is likely that the phascogale will have moved on and no images will be recorded; however, in this case there was an animal in the box at the time the camera was retrieved, so there was an opportunity for at least one animal trigger event. Why the camera did not respond to the animal's return is unknown. The camera has been working in other situations.

Quality assurance of cameras

The problem with camera 1PT was serendipitously discovered when multiple cameras were set up to record the same area. Although the camera had previously taken animal images, it had just been assumed that on its previous deployments no animals had passed through the detection zone during the night. Setting up at least two cameras together for testing, in preparation for deployment, would identify any such issues.

Acknowledgments

Thanks to Sally Bewsher and Ray Gibson of the Fauna Survey Group for their comments on the draft, and to other Fauna Survey Group members for their help in setting up and dismantling the cameras. Thank you to the anonymous referee for most helpful comments. Three of the cameras were funded through the FNCV Environment Fund and I thank the Club for its contribution. This project was carried out under DSE Flora and Fauna permit number 10004956.

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Received 16 May 2013; accepted 25 July 2013

Sugar Gliders photographed in nest box.

Sugar Gliders photographed by remote camera.